PB84-148840

Development of Chemical Countermeasures for Hazardous Waste Contaminated Soil

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Prepared for

Municipal Environmental Research Lab.
Edison, NJ

Jan 84

U.S. Department of Commerce
National Technical Information Service
NTIS

PB84-148840

EPA-600/D-84-039
January 1984

THE DEVELOPMENT OF CHEMICAL COUNTERMEASURES FOR HAZARDOUS WASTE CONTAMINATED SOIL

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EPA Contract 68-03-3113

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SPRINGFIELD, VA. 22161

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-600/D-84-039	2.
3. RECIPIENT'S ACCESSION NO. PB84 148840	
4. TITLE AND SUBTITLE THE DEVELOPMENT OF CHEMICAL COUNTERMEASURES FOR HAZARDOUS WASTE CONTAMINATED SOIL	5. REPORT DATE January 1984
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) W. D. Ellis, JRB; J. R. Payne, JRB A. N. Tafuri, EPA; F. J. Freestone, EPA	8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS JRB Associates 840 Westpark Drive McLean, Virginia 22102	10. PROGRAM ELEMENT NO. CBRD1A
	11. CONTRACT/GRANT NO. Contract No. 68-03-3113
12. SPONSORING AGENCY NAME AND ADDRESS Municipal Environmental Research Laboratory -- Cin., OH Office of Research and Development U. S. Environmental Protection Agency Cincinnati, Ohio 45268	13. TYPE OF REPORT AND PERIOD COVERED Conference Paper
	14. SPONSORING AGENCY CODE EPA/600/14

15. SUPPLEMENTARY NOTES

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16. ABSTRACT

The objective of this project is to evaluate the efficacy of in-situ treatment of large volumes of subsurface soils, and large, relatively quiescent waterbodies.

To date, efforts have concentrated on soils-related activities to determine whether significant enhancements to the in-situ cleanup of chemically contaminated soils with standard water washing techniques could be obtained by using aqueous surfactants. The addition of the surfactant mixtures was designed to improve the solvent properties of the water and enhance the removal of adsorbed chemical contaminants.

Laboratory studies were performed to determine the maximum cleanup efficiency under equilibrium conditions using water washes and a combination of 2% each of Hyonic PE90 (now known as NP90 by the manufacturer), and Adsee 799 (Witco Chemical) surfactants and to evaluate soil cleanup efficiency under gravity flow conditions. In general, overall soil cleanup approaching the 90 plus percent level was attained with intermediate molecular weight aliphatic and aromatic hydrocarbons, PCB mixtures and chlorinated phenol mixtures. Results appear to support additional larger scale studies and plans are being discussed to construct a soils test facility at EPA's Oil & Hazardous Materials Simulated Environmental Test Tank facility in New Jersey.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group

18. DISTRIBUTION STATEMENT RELEASE TO PUBLIC	19. SECURITY CLASS *(This Report)* UNCLASSIFIED	21. NO. OF PAGES 29
	20. SECURITY CLASS *(This page)* UNCLASSIFIED	22. PRICE

EPA Form 2220-1 (9-73)

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ABSTRACT

The U.S. Environmental Protection Agency's (EPA) Oil and Hazardous Materials Spills Research and Development Program in Edison, NJ has designed a Chemical Countermeasures Program (CCP) to evaluate in situ methods for mitigating or eliminating environmental damage from releases of toxic and other hazardous materials to the soils around uncontrolled hazardous waste disposal sites, and from spills of hazardous chemicals to still or relatively slow-moving surface water bodies. To date efforts have concentrated on soils-related activities to determine whether significant enhancements to the in situ cleanup of chemically contaminated soils with standard water washing techniques could be obtained by using aqueous surfactants.

Laboratory studies were performed to determine the maximum cleanup efficiency under equilibrium conditions using water washes and a combination of 2% each of Hyonic PE90 (now known as NP90, Diamond Shamrock), and Adsee 799 (Witco Chemical) surfactants and to evaluate soil cleanup efficiency under gravity flow conditions. In general, overall soil cleanup approaching the 90 plus percent level was attained with intermediate molecular weight aliphatic and aromatic hydrocarbons, PCB mixtures and chlorinated phenol mixtures. Results appear to support additional larger scale studies, and plans are being discussed to construct a full-scale controlled-condition soils test facility at EPA's Oil and Hazardous Materials Simulated Envivonmental Test Tank facility in New Jersey.

INTRODUCTION

The "Comprehensive Environmental Response, Compensation, and Liability Act of 1980" or "Superfund" recognizes the need to develop countermeasures (mechanical devices, and other physical, chemical, and biological agents) to mitigate the effects of hazardous substances that are released into the environment and are needed to clean up inactive hazardous waste disposal sites. One key countermeasure is the use of chemicals and other additives that are intentionally introduced into the environment for the purpose of controlling the hazardous substance. The indiscriminate use of such agents, however, poses a distinct possibility that the release situation could be made worse by the application of an additional chemical or other additive.

The U.S. Environmental Protection Agency's Oil and Hazardous Materials Spills Branch in Edison, NJ has initiated a support program to define technical criteria for the use of chemicals and other additives at release situations of hazardous substances such that the combination of the released substance plus the chemical or other additive, including any resulting reaction or change, results in the least overall harm to human health and to the environment.

The Chemical Countermeasure Program has been designed to evaluate the efficacy of in situ treatment of large volumes of subsurface soils, such as found around uncontrolled hazardous waste sites, and treatment of large, relatively quiescent waterbodies contaminated with spills of water-soluble hazardous substances. For each situation, the following activities are planned:

a. A literature search to develop the body of existing theory and data;

b. Laboratory studies on candidate chemicals to assess adherence to theory and define likely candidates for full-scale testing;

c. Full-scale, controlled-condition, reproducible tests to assess field operation possibilities; and

d. Full-scale tests at a site-of-opportunity.

This paper presents the results of the information search and laboratory studies for the soils-related activities of the Program.

INFORMATION SEARCH

A literature search of limited scope was performed to gather information on the state-of-the-art in chemical countermeasures. The emphasis of the search was on the most recent and innovative work on the subject, and on work most likely to be fruitful for further development. The search was primarily directed toward readily available publications on subjects related to chemical countermeasures, and toward contacting key people doing research, development, and field implementation of chemical countermeasures.

The application of chemical countermeasure techniques in the field has been very limited. The main reasons are caution and scarcity of information/experience. Current technology for removal of contaminants from large volumes of soils (too large to excavate economically) having relatively low to moderate levels of contamination has been limited to withdrawal of groundwater, with or without recharge to the soil, i.e. in-situ "water washing". Accordingly, the laboratory studies were designed to determine whether significant enhancement to the efficiency of contaminated soils cleanup by water washing could be obtained by adding aqueous surfactants to recharge water used in a continuous recycle. Based on the literature it was felt that surfactant mixtures

would improve the solvent properties of the recharge water thereby enhancing the removal of chemical contaminants adsorbed onto soil particles. This approach was a direct derivative of the laboratory studies performed by the Texas Research Institute for the Amercan Petroleum Institute on the use of surfactants for enhanced gasoline recovery from sand.[1]

LABORATORY PROGRAM DESIGN

The experimental design of the laboratory program was formulated after reviewing the results of similar investigations identified during the information search. The primary purpose of the laboratory studies was to determine whether significant enhancements to the in-situ cleanup of chemically contaminated soils with standard water washing techniques could be obtained by using aqueous surfactants. A secondary objective (assuming the primary goal was successful) was to obtain information and make recommendations for designing larger scale tests under controlled conditions and field tests at sites of opportunity.

Before conducting the laboratory studies, a number of specific issues had to be resolved. The first issue involved the identification and selection of a suitable soil to be used in the laboratory tests and included soil characterizations and evaluation of permeability versus compaction parameters. The second issue involved contaminant selection and determination of the concentrations required for soils studies. The third issue dealt with surfactant selection, surfactant solubility, compatibility with soil type,

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[1] Texas Research Institute, Inc. 1982b. Test Results of Surfactant Enhanced Gasoline Recovery in Large-Scale Model Aquifer. The American Petroleum Institute, Washington, DC, April.

and efficiency of pollutant removal. The fourth issue involved the analytical methods to be used for extraction and analysis for the pollutant groups of interest in the soils and leachates.

Selection of Test Soil

In choosing the soil to be used in the tests, native soils at each of 10 Region II Superfund sites were identified to determine the most commonly occurring soil series. Once determined, a soil type of the same taxonomic classification was located in the vicinity of the potential larger-scale test facility which could be excavated and used in the experiments. The most commonly occurring classification was Typic Hapludults (Freehold Soil), a fine-to-coarse loamy soil of humid climates, containing zones of clay accumulation. In addition to taxonomic classification a permeability rating of 10^{-2} to 10^{-4} cm/sec was specified as a desirable range.

Table 1 presents the grain size distribution obtained by wet sieve and pipet analyses. Approximately 95% of the theoretical surface area is represented by fines (15% silt and 8% clay).

To determine the mineralogical composition of the Freehold soil, X-ray diffraction studies were undertaken. The results showed quartz and feldspar to be the only measurable constituents. Quartz was the major phase, representing at least 98% of the total weight. No measurable amounts of clay minerals appeared.

The total organic carbon content (TOC) of the soil was determined on a sample of soil prepared by grinding and suspending in a aqueous solution of phosphoric acid and sodium phosphate, in accordance with EPA Method 415.1. The TOC value was 0.12% by weight. This relatively low level of organic

matter in the soil implies a relatively low adsorption potential for organic contaminants.

The cation exchange capacity (CEC) of the soil was also determined by the methods of Jackson[2]; and the results were combined to yield the total CEC. The result was 816 milliequivalents per 100 gms, an extremely low value, confirming the absence of mineralogic clay in the soil.

Table 1. Grain size distribution of Freehold Soil by wet sieve and pipet analyses (Modified ASTM D-422 using U.S. Bureau of Soils sieve sizes)

Class	Size Range (μm)	Mass (percent)	Theoretical Surface Area (percent)
Gravel	>1000	16	<.05
Sand	62 to 1000	61	5
Silt	8 to 62	15	34
Clay	<8	8	61

Selection of Contaminants

The compounds used for testing in the laboratory were chosen based on the criteria that they should:

a. Occur frequently in high enough concentrations in the soil surrounding Superfund sites;

b. Present a significant hazard to human health and the environment;

c. Have low to moderate mobility and high persistence in soil;

d. Be treatable by an existing chemical method; and

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2 Jackson, M.L., 1970. Soil Chemical Analysis. Prentis-Hall, Inc. Sixth Printing Department on Soil Science, University of Wisconsin, Madison, WI. pp 57-71.

e. Have an appropriate chemical analogue, if too hazardous or expensive for experimentation.

Data was gathered on the concentrations, frequency of occurrence, soil adsorption, and toxicity of waste chemicals found at Superfund sites. The incidence of the various hazardous waste and waste classes is presented in Table 2. The data on soil contaminants indicate that the most widespread class of contaminant is the slightly water soluble organics, which includes low molecular weight aromatics and halogenated hydrocarbons. The next most common contaminant classes are heavy metals and hydrophobic organics. Clearly, the occurrence of PCB's, aromatics, and phenols is also widespread.

Based on this review and analysis, three pollutant compound mixtures were selected for use in soil testing:

(1) Intermediate and high molecular weight aliphatic hydrocarbons and polynuclear aromatic hydrocarbons (high boiling distillate fraction of Murban crude oil)

(2) Polychlorinated biphenyl (PCB) mixture in chlorobenzenes (Askarel®)

(3) Di-, tri-, and pentachlorophenols.

Selection of Surfactants

The preliminary selection of 2% Richonate YLA and 2% Hyonic NP90 as the surfactant mixture was based on the results of the Texas Research Institute study[3] evaluating the removal of gasoline from pure Ottawa Sand. After initial studies, however, this mixture was found to be unsuitable due to the

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[3] Texas Research Institute, Inc. 1979. Underground Movement of Gasoline on Groundwater and Enhanced Recovery by Surfactants. The American Petroleum Institute, Washington, DC.

Table 2. Hazardous Soil Contaminants at Superfund Sites

Soil Contaminants	Number of Sites	Total Sites	Examples
Heavy Metal Wastes		47	
Chromium	9		
Arsenic	8		
Lead	7		
Zinc	5		
Cadmium	4		
Iron	3		
Copper	2		
Mercury	2		
Selenium	2		
Nickel	1		
Vanadium	1		
Fly ash	1		
Plating wastes	2		
Other Inorganics		26	
Cyanides	6		
Acids	7		sulfuric acid
Alkalis	6		lime, ammonia
Radioactive wastes	3		uranium mining and purification wastes, radium, tritium
Miscellaneous	4		beryllium, boron hydride, sulfides, asbestos
Hydrophobic Organics		38	
PCB's	15		
Oil, grease	11		
Volatile hydrocarbons	6		Varsol, hexane
Chlorinated hydrocarbon pesticides	5		endrin, lindane, DDT, 2,4,5-T dieldrin
Polynuclear aromatics	1		

Table 2. Hazardous Soil Contaminants at Superfund Sites (continued)

Soil Contaminants	Number of Sites	Total Sites	Examples
Slightly Water Soluble Organics		64	
Aromatics			
Benzene	9		
Toluene	8		
Xylene	5		
Other aromatics	3		styrene, naphthalene
Halogenated hydrocarbons			
Trichloroethylene	11		
Ethylene dichloride	6		
Vinyl chloride	4		
Methylene chloride	3		
Other halogenated hydrocarbons	15		chloroform, trichloroethane, tetrachloroethylene, trichlorofluoromethane
Hydrophilic Organics		20	
Alcohols	4		methyl, isopropyl, butyl
Phenols	12		picric acid, pentachlorophenol creosote
Other hydrophilics	4		dioxane, bis(2-chloroethyl) ether, urethane, rocket fuel
Organic solvents (unspecified) and other organics		30	dioxin, dioxane, dyes, pigments, inks, paints, nitrobenzene

mixture's marked tendency to suspend the silt and clay size grains (less than 63 μm in diameter), which resettled in small pores, thereby inhibiting column flow.

Beaker studies were then conducted to evaluate solubility properties of the surfactants and their tendency to disperse the fine clay-size particles present in the Freehold soil.

The decision was made to use a combination of 2% Adsee 799 and 2% NP90, nonionic surfactants, based on the mixture's:

- High water solubility
- Ability to disperse Murban hydrocarbons
- Minimal suspension of fine soil particles
- Lower content of compounds that cause analysis interferences than previously tested surfactants.

Analytical Procedures

The analysis of contaminated soils and aqueous leachates involved solvent extraction, liquid chromatography (fractionation into aliphatic, aromatic, and polar fractions), and instrumental analysis by Gas Chromatography (GC) using Flame Ionization Detectors (FID) and Electron Capture Detectors (ECD), and High Performance Liquid Chromatography (HPLC).

For leachates in which aromatic hydrocarbons or PCB's were present, EPA Method 608 was followed. The Murban hydrocarbon contaminant extracts were analyzed by FID-GC.

The extract from the PCB (Arochlor 1260) contaminant leachate was analyzed by ECD-GC without silica gel fractionation.

For the leachate containing chlorinated phenols, EPA Method 625 was used. The leachate was subjected to the acid/phenol extraction step only, and then analyzed by HPLC.

Soil samples were prepared for pollutant analysis using a rigorous shaker table extraction procedure which has been shown to yield comparable results to Soxhlet extraction.

LABORATORY EXPERIMENTATION

The laboratory experimentation was conducted in two phases. The first phase involved shaker table agitation (equilibration) to determine the soil/aqueous surfactant partitioning of the pollutants. This compared the maximum cleanup efficiency under conditions of water washes and 4% aqueous surfactant washes with thorough agitiation. The combination of 2% each of Hyonic NP90 (Diamond Shamrock) and Adsee 799 (Witco Chemical) in water was used.

After the surfactant efficiency was determined in the shaker table tests, the soil column studies were performed to evaluate soil cleanup efficiency under gravity flow conditions. In the column studies, different concentrations of the three pollutant groups were used. The concentration of Murban hydrocarbons was 1,000 ppm in the soil; the concentration pf PCB's was 100 ppm; and the concentration of chlorinated phenols was 30 ppm.

Shaker Table Studies

Table 3 presents the experimental design for shaker table agitation/equilibration of contaminated soils with aqueous surfactant. A total on nine contaminated soil samples plus three controls (not shown in the table) were prepared. All 12 samples (30-100 g each) were placed in 500 ml Teflon® screw cap jars and subjected to a water wash (200 ml), with the leachate from the first and second samples being analyzed after the first water wash and the soil from the first sample being sacrificed for analysis after the first water wash. The remaining 11 samples were then subjected to a second water

TABLE 3. Experimental Design for Shaker Table Agitation/Equilibration of Contaminated Soils.

Replicate Sample Number	Initial Water Equilibration			Water Plus Surfactant Equilibration			Final Water Equilibration		
	1st Wash	2nd Wash	3rd Wash	1st Wash	2nd Wash	3rd Wash	1st Wash	2nd Wash	3rd Wash
1	Extract Soil Examine leachate	0[a]	0	0	0	0	0	0	0
2	Examine leachate	Extract Soil Examine leachate	0	0	0	0	0	0	0
3	—[b]	Examine leachate	Extract Soil Examine leachate	0	0	0	0	0	0
4	—	—	Examine leachate	Extract Soil Examine leachate	0	0	0	0	0
5	—	—	—	Examine leachate	Extract Soil Examine leachate	0	0	0	0
6	—	—	—	—	Examine leachate	Extract Soil Examine leachate	0	0	0
7	—	—	—	—	—	Examine leachate	Extract Soil Examine leachate	0	0
8	—	—	—	—	—	—	Examine leachate	Extract Soil Examine leachate	0
9	—	—	—	—	—	—	—	Examine leachate	Extract Soil Examine leachate

a - "0" indicates no action taken because sample was utilized (destroyed) during sampling.

b - "—" indicates no analytical activity, i.e., the soil is saved for the next step.

wash (200 ml), with the soil from the second jar being sacrificed for analysis, as well as the leachate from that sample and the leachate from the third jar being analyzed, etc. In this manner, as illustrated in Table 3, soil and leachate were analyzed after each of the three initial water equilibrations; after each of three water plus surfactant equilibrations (200 ml each); and after each of three final water-rinse equilibrations (200 ml each). Each soil/solution mixture was vigorously agitated for a half hour, and then centrifuged to separate the aqueous and soil phases.

Soil Column Studies

The columns used in this study were glass, 7.6 cm (3 in.) I.D. by 152 cm (5 ft). Both ends of the column were sealed with nippled glass caps. A Teflon® O-ring placed between the glass column and cap sealed the two surfaces as they were crimped together by an adjustable stainless steel jacket. Teflon® tubes connected to the caps allowed the introduction of the aqueous solution and the collection of the leachate.

The test soil was prepared by spreading a uniform layer in aluminum pans to a depth of approximately 1.3 cm (0.5 in.) and treated with a fine aerosol spray of the contaminant mixture dissolved in methylene chloride. The methylene chloride was allowed to evaporate, after which the soil was mixed by stirring with a stainless steel spatula.

Contaminated soil was packed into the columns using the following procedure. A plug of glass wool was pushed to the bottom of the column. Soil weighing approximately 775 g (1.7 lbs) was then added to the column and packed to a height of 10.2 cm (4 in.) using a controlled-drop hammer compactor designed to fit inside the column. Following compaction of each lift, the

soil was tested with a pocket penetrometer to determine the compaction. The soil was packed to a total height of 0.92 m (3 ft) and compacted to a density of 1.68 to 7.76 gm/cm^3 (105 to 110 lbs/ft^3).

A falling head permeability test, using modified American Society for Testing and Materials methods because of column design, was performed on one of the control columns prior to starting the column tests. Head level fall from the initial starting point was measured over time while maintaining a constant head level at the outflow. Permeabilities (K) were calculated from the following standard equation:

$$K = (2.3\ L/t) \log_{10} (h_0/h_1)$$

where:

L = length of soil sample (cm)

t = elapsed time (sec)

h_0 = original head level (cm)

h_1 = head level after elapsed time t (cm)

Permeabilities measured in this manner ranged from 1.1×10^{-3} to 9.0×10^{-4} cm/sec (3.6×10^{-5} to 3.0×10^{-5} ft/sec).

Figure 1 presents an overview of the column setup during an experiment. Water or aqueous surfactant was gravity-fed under a constant 61 cm (2 ft) head pressure to the top of each column via Teflon® tubing from reservoir carboys and collected below after passing through the column. Leachate was collected and analyzed for pore volumes 1 through 3, pore volumes 4 through 7 and pore volumes 3 through 10 for each treatment.

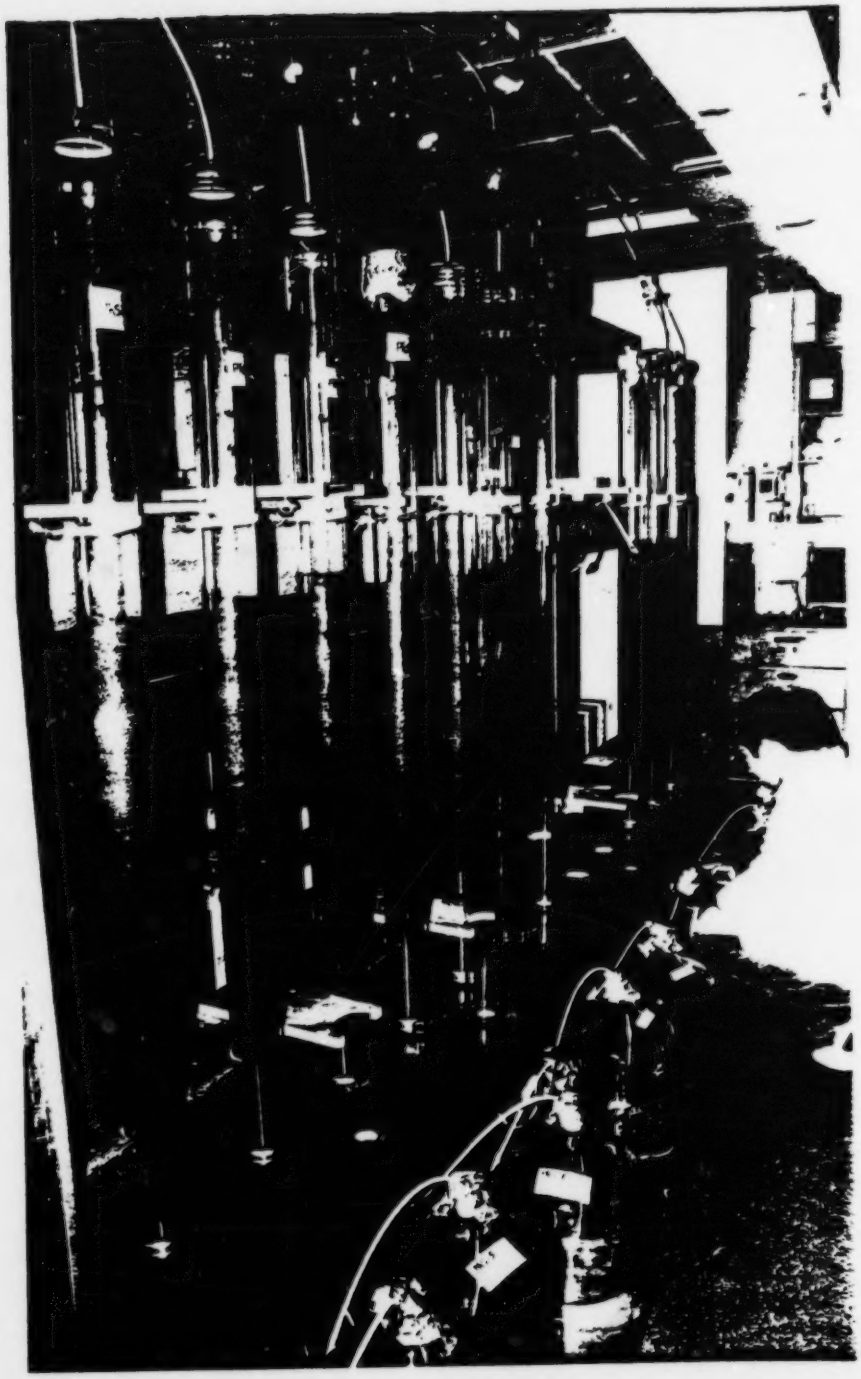

FIGURE 1. Overview of soil columns in a column rack designed to support water and surfactant carboys at a constant height above columns. Surfactant and water were introduced to each column through the teflon tubing in each 20 liter (5.3 gal) glass carboy above the rack. Leachate eluting from each contaminated soil column was collected in the glass carboys shown in the foreground.

RESULTS

Murban Contaminated Soil

The quantitative data are illustrated in Figure 2 as a bar graph of total hydrocarbons present in soil and leachate after each step in the shaker table experiments. The data in the graph illustrate that very little cleanup of the soil occurred during the first three water washes, but a significant reduction (down to 41% of original levels) was obtained after the initial aqueous surfactant wash. Continued improvement in hydrocarbon removal was observed in the second and third equilibration with aqueous surfactant. Gradual removal of surfactant and residual hydrocarbons was then observed in the three final water washes. In general, overall mass balance approaching 95% was obtained in the shaker table experiment.

In the soil column studies with Murban, very limited removal of aliphatic hydrocarbons from the soil occurred even after 10 pore volumes of initial water. After three pore volumes of aqueous surfactant, however, the soil material was significantly cleaner, and after the final 10 pore volumes of water rinse, the soil was effectively decontaminated.

Significant levels of aromatic hydrocarbons were present in the soil after 10 initial water washes. After the first three aqueous surfactant washes, however, the aromatic components were completely removed, and all that remained in the soil were components from the surfactant material itself.

Soil column and leachate data are represented graphically in Figure 3 which presents the relative contaminant concentration in the soil and leachate after each water/surfactant treatment. The distillation fraction concentration ranged from 80 to 100% during the first three water washes and then dropped to approximately 10% during the surfactant treatment, with 70-80% of the original

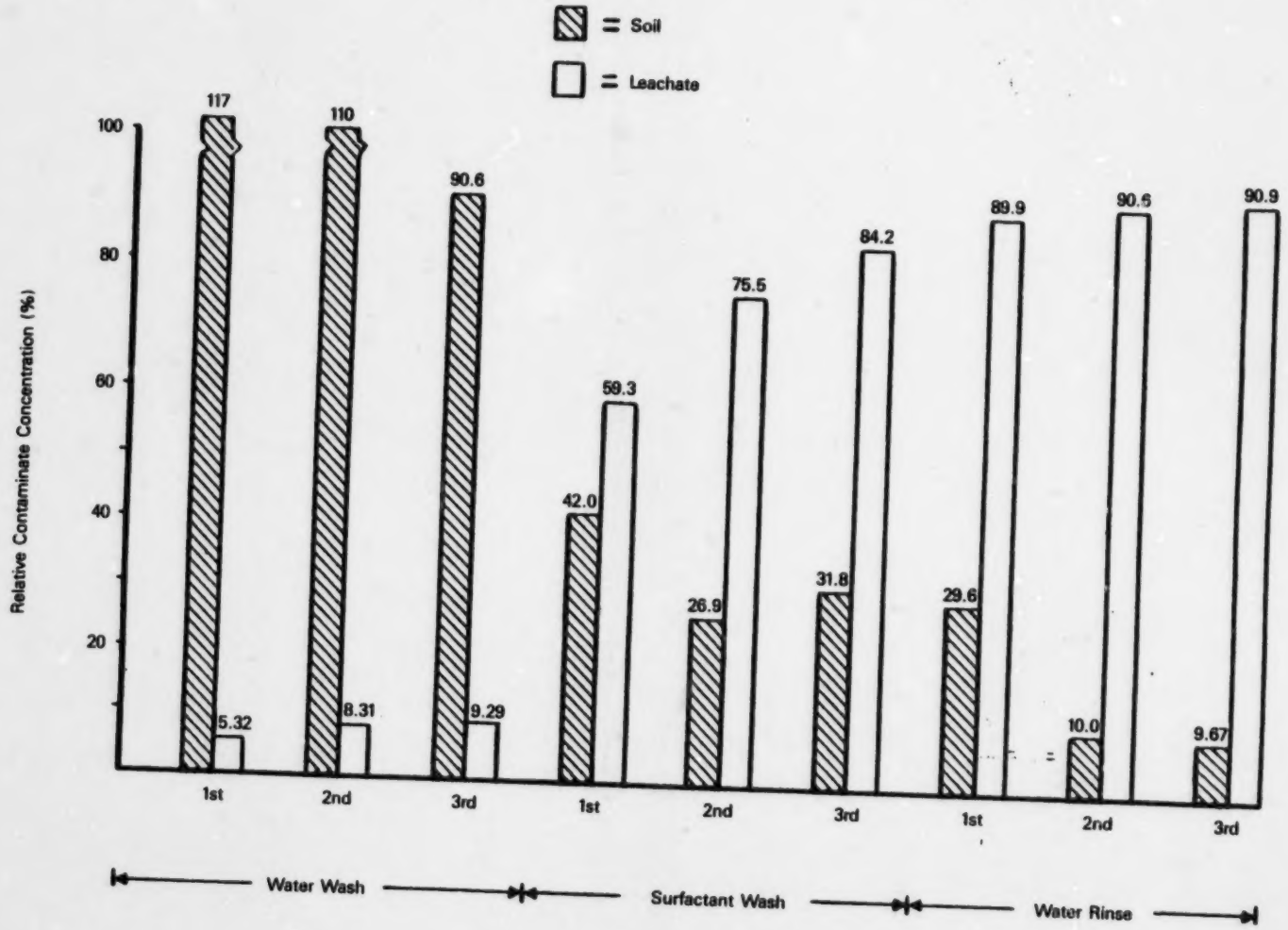

Figure 2. Murban Distillation Fraction Shaker Table Results

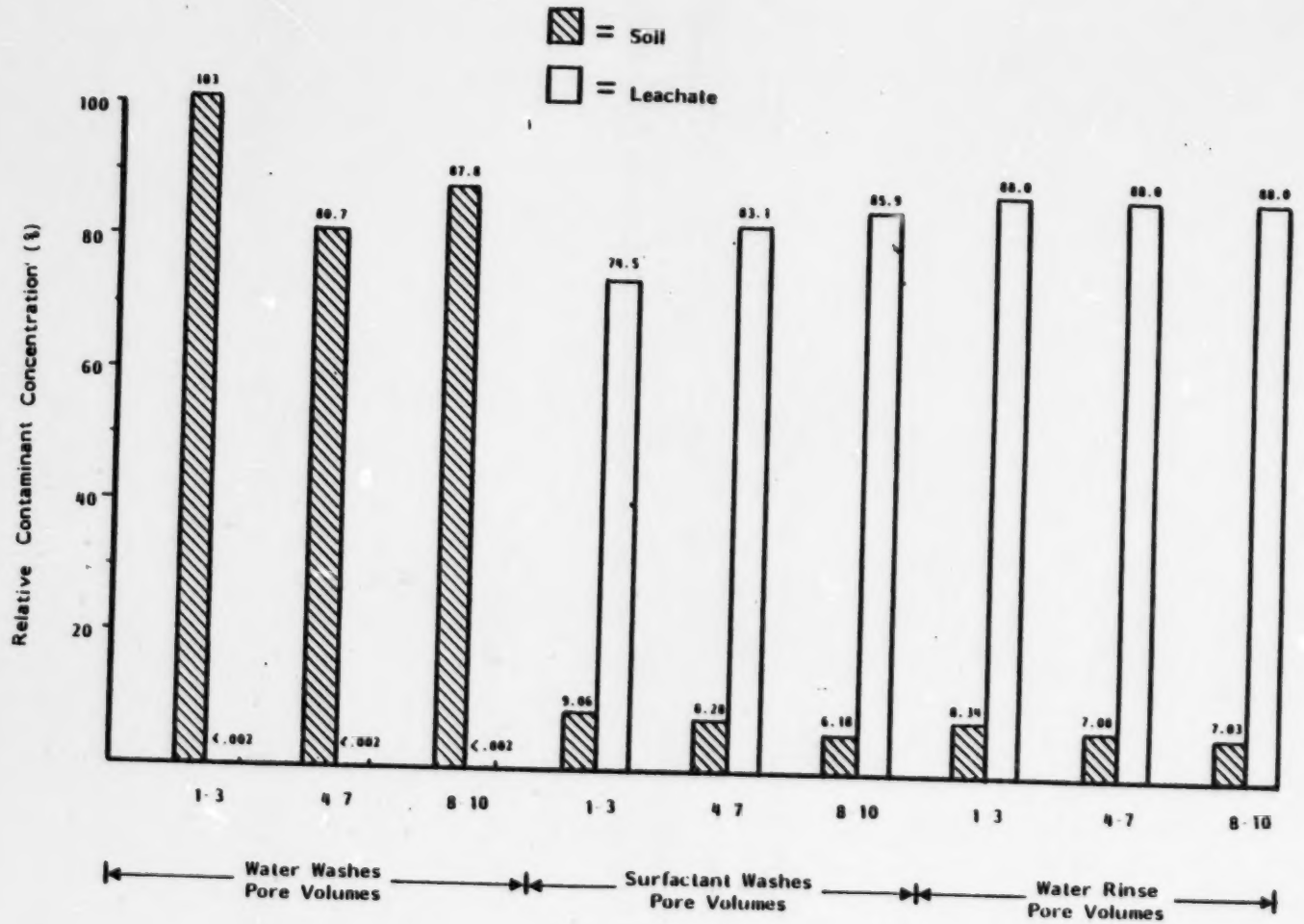

FIGURE 3 Results from Murban Distillation Fraction Column Experiments.

hydrocarbons observed in the aqueous surfactant leachate. The final three water washes did not affect any additional cleanup of the soil, and the average residual soil concentration was about 7% of the initial spiked distillation fraction concentration.

PCB Pollutant Mixture

The initial PCB shaker table experiments followed the same protocol as that described for the Murban hydrocarbons.

Figure 4 presents a graphic illustration of PCB cleanup from the shaker table experiments. After the first surfactant wash, the soil PCB concentration decreased to approximately 25% of the original level, with 45% of the original PCB's accounted for in the aqueous surfactant at that point. Additional surfactant rinses produced even greater cleanup of soil PCB's, with up to 62% of the original PCB material present in the surfactant after the third aqueous surfactant equilibration. An overall removal of approximately 67% of the original PCB's after the three final water rinses was finally obtained.

As in the shaker table studies, very little cleanup of the soil column was affected with the water washes, while significant removal of PCB's was observed after pore volumes 1-3 of aqueous surfactant. The data are illustrated graphically in Figure 5, which shows the overall concentrations of PCB's in the soil and leachate after each successive treatment. The effect of the first aqueous surfactant wash from the soil column was a 90% reduction in PCB concentration in the soil column. During the three final water rinses, the overall PCB concentrations were reduced to less than 2% of the initial value. An overall mass balance of approximately 70% was obtained.

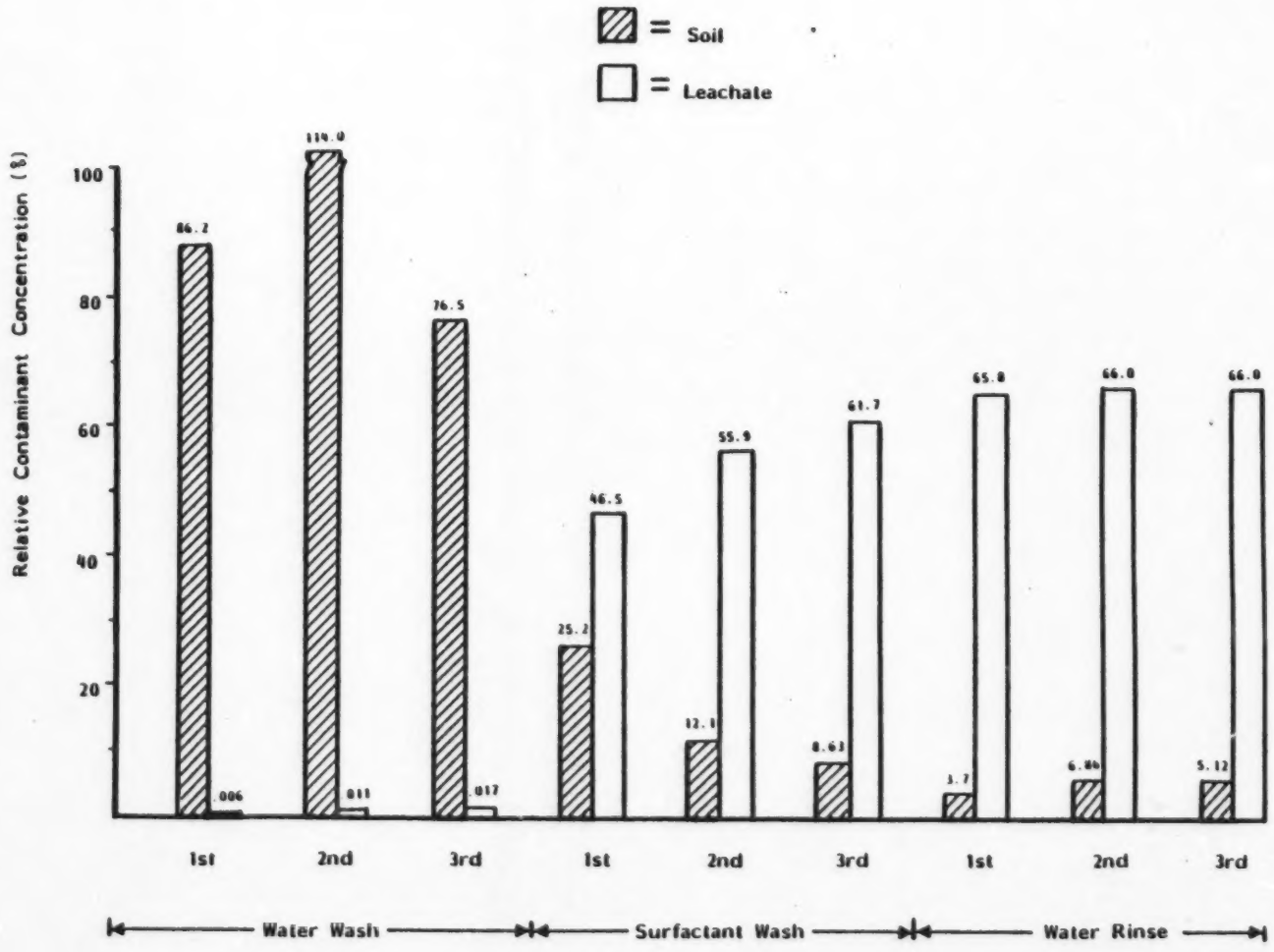

FIGURE 4 PCB Recovery Results from Shaker Table Experiments.

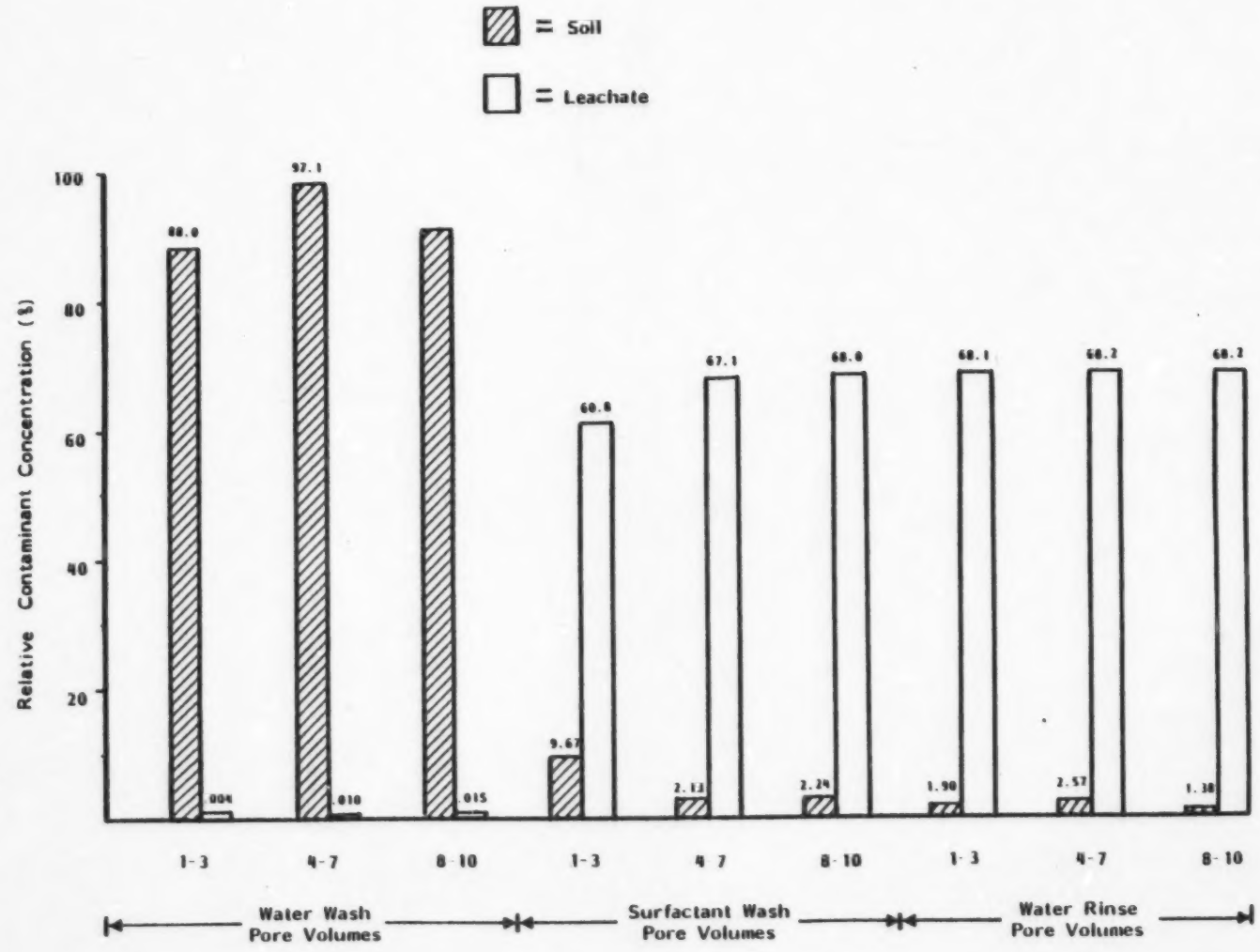

FIGURE 5 PCB Recovery Results from Soil Columns.

Chlorinated Phenols Pollutant Mixture

The overall cleanup of phenols in the soil is illustrated graphically in Figure 6. It is clear that before initial treatment, approximately 93% of the added di-, tri-, and pentachlorophenol mixture was associated with the soil. After the three water washes, however, the residual contamination of the chlorinated phenol group in the soil had dropped to 2% of the amount originally present. Pore volumes 4-7 and 8-10 increased the final proportion of chlorinated phenol in the leachate to approximately 70% of the amount added to the soil originally, and the residual chlorinated phenol in the soil dropped to approximately 0.5% of the value originally introduced.

CONCLUSIONS/RECOMMENDATIONS

The shaker table studies and the soil column studies showed that the 4% aqueous solution of surfactants was extremely effective in removing hydrophobic and slightly hydrophilic organics from the test soil. The performance of the aqueous surfactants in removing PCB's from the soil was quite similar to their performance with the Murban distillation fraction. However, water alone was sufficient to decontaminate the chlorophenols contaminated soil.

A small amount of aqueous surfactants solubilized substantial amounts of two lipophilic contaminant mixtures from the test soil. Although the surfactants were chosen for this function, the relative ease of removal of the contaminants from the soil is partly because of the soil's characteristics. The TOC of the Freehold soil used in the laboratory tests was 0.12%; this is somewhat low, and values of 0.5 to 1.0 percent might be expected for a soil mixture of A, B, and C horizons. At higher TOC values, organics would be removed from the soil less readily.

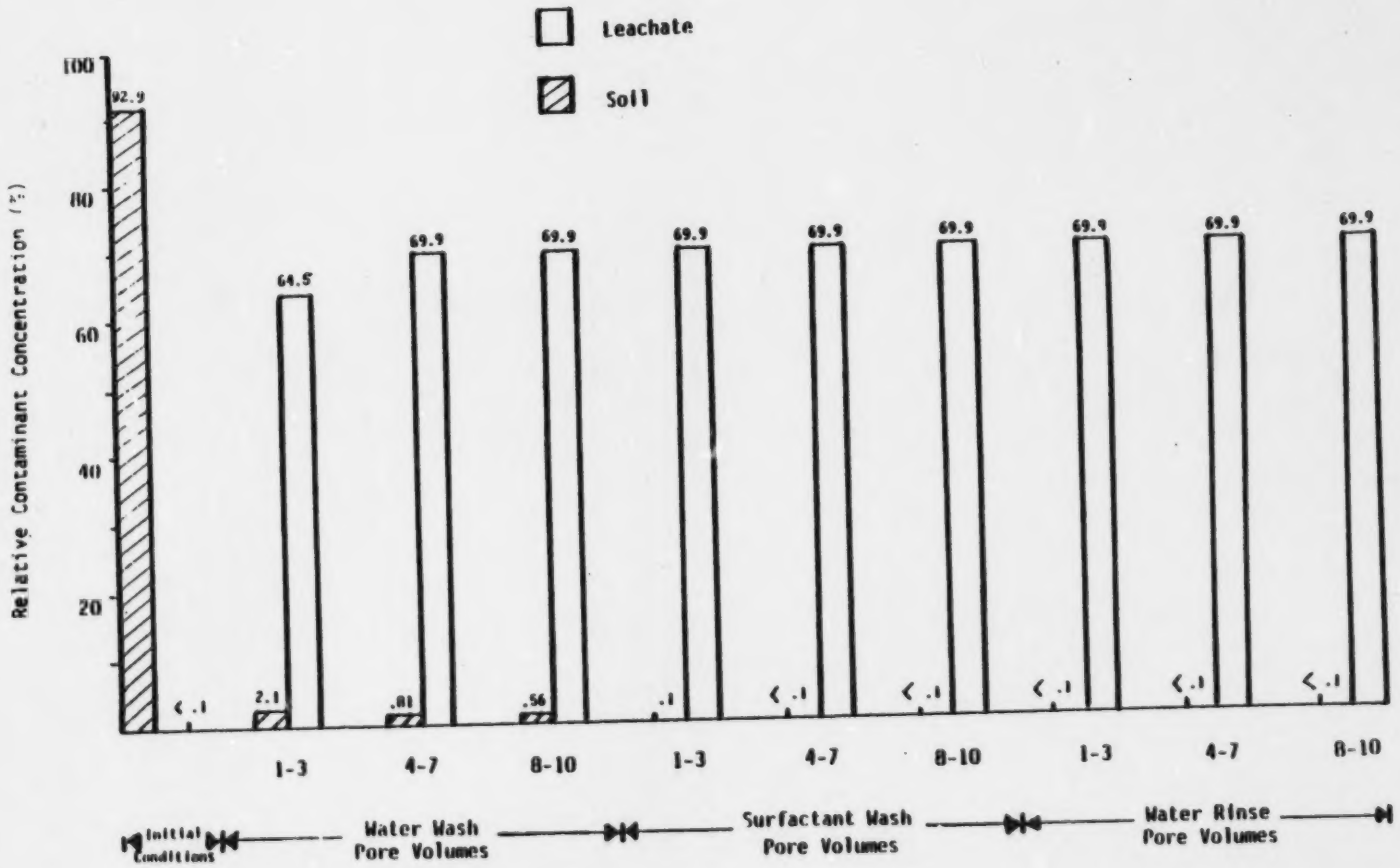

FIGURE 6 Results from Chlorinated Phenol Column Experiments (Concentrations Summed for Di-, Tri-, and Penta chlorophenol.

The results of the soil column tests with Murban and PCB's paralleled the shaker table test results. Because of their hydrophobic nature, little of the contaminants was removed by the initial water washes, while the aqueous surfactants removed them from the soil quite efficiently. The aqueous surfactant appeared to be somewhat more effective in the column tests than in the shaker table tests.

For instance, in the Murban shaker table study, 50% of the contaminant was removed from the soil by treatment with 2 ml of aqueous surfactant per gram of soil. In the Murban soil column study, 74.5% of the contaminant was removed by only 0.8 ml of aqueous surfactant per gram of soil. The shaker table tests were equilibration tests, and should therefore demonstrate optimum efficiency of the surfactant solution in removing the contaminants. The column tests were flow-through tests, but showed more efficient removal of contaminant, probably because the surfactant-solubilized contaminant micelles which formed solubilized more and more of the contaminant as they flowed in suspension down the column. The effect is similar to that observed in certain tertiary oil recovery processes[4].

The results of the laboratory studies appear encouraging and in support of continuation of the Chemical Countermeasures Program into larger-scale controlled-conditioned testing. Such a test facility would offer the advantages of:

- Three-dimensional scale approaching field application;
- Water table with gradient;

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[4] Klins, M.A., S.M. Farougali, and C.D. Stahl. 1976. Tertiary Recovery of the Bradford Crude by Micellar Slugs and Three Different Polymer Buffers. ERDA Contract No. E (40-1)-5078.

- Time cycle for weather conditions;
- Sampling and monitoring easily implemented;
- Leakage collection; and
- Moderate soil waste generated.

Accordingly, EPA's Oil and Hazardous Materials Spills Program at Edison is entertaining the concept of constructing a large-scale test facility (Chemical Additive Treatment Tank) to bridge the gap between laboratory studies and field application.

PROPOSED PILOT SCALE TEST FACILITY

The Chemical Additive Treatment Tank (Cat-Tank) would provide an environmentally safe facility for the demonstration and evaluation of techniques and equipment designed to clean up and control hazardous substance spills and unintentional releases from hazardous waste dump sites. Preliminary design includes an open top, lined, concrete tank, capable of containing 934 m^3 (1222 yd^3) of test soil. The test surface would be 17.4 m (55 ft) long by 9.5 m (30 ft) wide with a soil depth of 6.3 m (20 ft). Also included is a leak prevention system made up of a primary and secondary 80-mil thick, high density polyethylene liner. The primary liner would contain the test soil and the secondary liner beneath it would enclose the leak detection underdrain-- a perforated pipe network situated between the two liners, and emptying by gravity flow into a polyethylene-line leak collection sump. The secondary leak detection system consists of monitoring wells placed down (hydraulic) gradient from the CAT-Tank.

The CAT-Tank would be enclosed by a 3.8 m (12 ft) high nonclimbable fence. Within the fence would be a decontamination area appropriately equipped for the particular contaminants being tested.

The CAT-Tank presents a unique environment in which numerous experimental investigations could be safely and effectively carried out. The following is a partial list of potential uses:

a. Evaluation of in-situ soil "washing" technology;

b. Evaluation of commercial subsurface water samplers;

c. Evaluation of commercial subsurface water flow meters;

d. Demonstration of grouting materials and methods;

e. Demonstration of slurry trench techniques for cutoff and isolation walls;

f. Demonstration of slurry trench backfill materials for long-term isolation;

g. Demonstration of synthetic fabric "geomembranes" for long-term isolation;

h. Demonstration of a leak detection scheme for cutoff walls and liners to monitor top, sides, and bottom of a containment area;

i. Demonstration of pipeline/underground storage tank leak detection methods;

j. Evaluation of the efficiency of "soil washing machine" technology;

k. Test "fixing" of certain pollutants to soil, i.e., organics.

Figure 7 indicates a plan and side view of the proposed CAT-Tank facility.

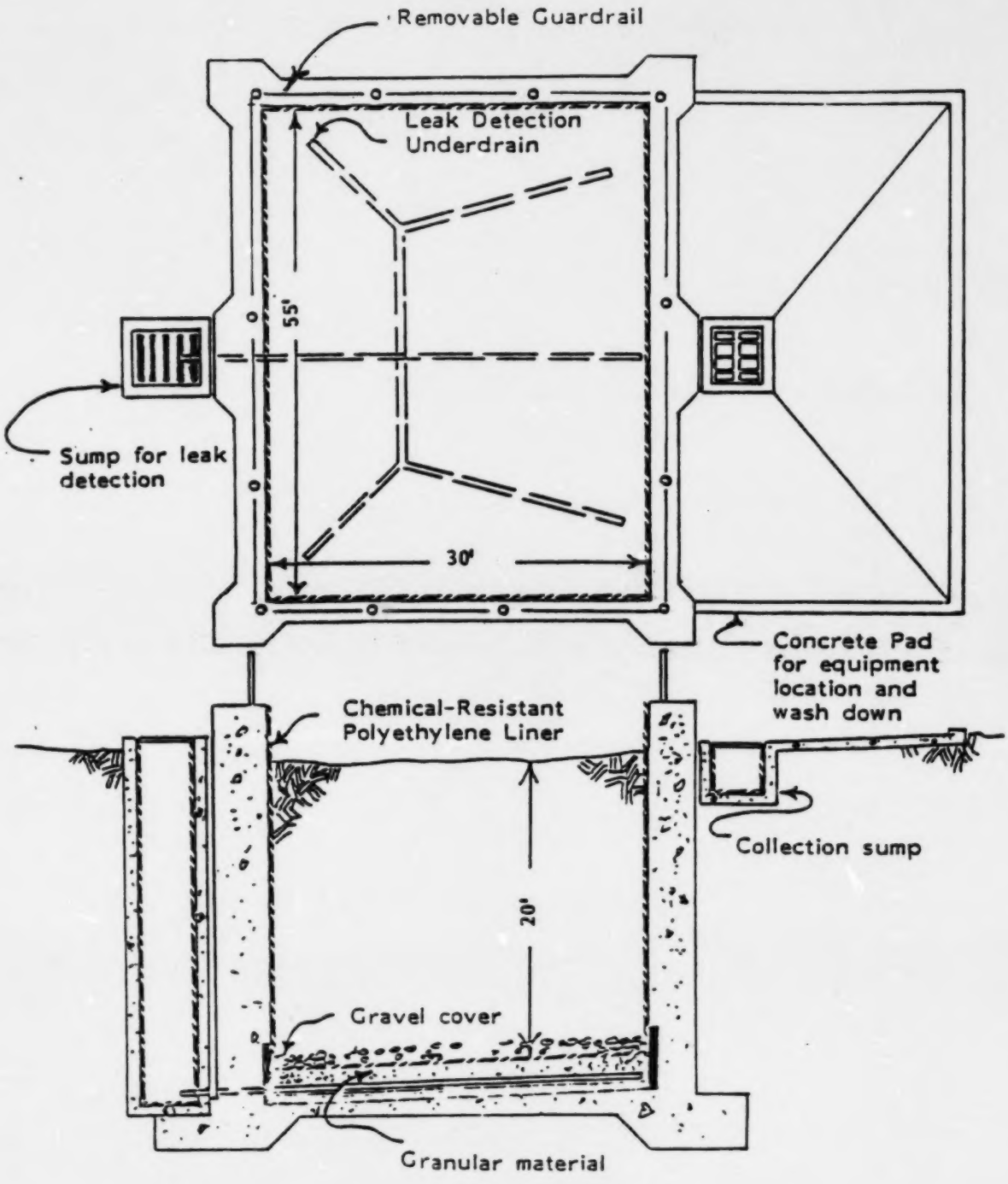

Figure 7. Plan View of proposed CAT-Tank (top)
Side view of proposed CAT-Tank (bottom)